Department of Agriculture, Trade and Consumer Protection

Division of Agricultural Development

Agricultural Development & Diversification Program (ADD)

Grant Project Final Report

Contract Number: 19001

Grant Project Title: Biorefined Products

Project Beginning Date: July 1, 2004 Project End Date: November 1, 2004

Amount of Funding Awarded: $29,000

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Submitted by: Bob Sather Date: November, 2004

Introduction

Biorefining is a process used to maximize the extraction of marketable co-products naturally found in crop plants or other organic materials. Biorefining is similar to petroleum refining industry, except that local, renewable biomass materials are the feed stock rather than crude oil.

Advantages and benefits of Biorefining versus current chemical processes -

- reduces waste streams
- creates new jobs and business
- creates valuable products from renewable agriculture and biomass products
- reduces our dependency on fossil fuels
- generates wealth for our state and promotes new markets for agriculture products
- uses unexploited products from agriculture
- develops less expensive and better performing products
- reduces dependency from crude oil and other hydrocarbons
- mitigates projected global climate change through reduction of buildup of atmospheric carbon dioxide

Several years ago, Biorefining Inc. conducted empirical laboratory research on a biorefining process with collaborative help from the University of Minnesota Biorefining laboratories. The process used steam explosion and led to the development of a patented crystallization process for refining biomass into high-value sugars. Although the original research was on a micro scale, the work did support the feasibility to commercialize high-value sugar biorefining.

The specific purpose of this grant project was to evaluate several low value agriculture pulp materials that could be biorefined commercially to produce- Pectin, L-Arabionse, Galactose, Xylose and Manose. These products are use as additives to food products as well as pharmaceutical and nutraceutical products. The pulp materials tested were: (1) dry mill distiller's grain, a byproduct of ethanol production, (2) wet mill distiller's grain, (3) sugar beet pulp, and (4) we are currently testing cranberry pulp.

Comparable Value of Stock Feed to Market Vale of Sugars Per Kilogram

(1 Kilogram= 2.2 Pounds)

The value of sugar beet pulp and distillers grain is a little less than one cent a kilogram

Product	**Value**
Pectin	$25.00/kg
L-Arabinose	$140.00/kg
Galactose	$125.00/kg
Xylose	$3.00/kg
Mannose	$150.00/kg

The Steam Explosion Process

The commercialization, by ACE Biorefining, LLC will be the first in the world to apply the Steam Explosion/Crystallization Process to the biorefining of high-value sugars. Currently, all of the high value products listed above are extracted through a wet chemical process. None of the products are produced in the United States because so much sulfuric acid is used and environmental permitting would be too costly. However we now know that we can commercially biorefine these products at about 10% of the wet chemical process. No chemicals will be used in the Biorefining process.

Batch steam explosion was originally developed in the 1930s, but manufacturers have only recently used continuous steam explosion processes. In the Steam Explosion Process, the raw feedstock material (e.g. distiller's grain, sugar beet pulp and cranberry pulp) is exposed to high-pressure steam and then explosively discharged back to atmospheric pressure levels. Under the right processing conditions the biomass anuthohydrolyzes "gross" fractions. This separates higher value fibers (hemi-cellulose) from the low value stock material (cellulose). The higher-value fibers are centrifuged and processed through an ion exchange to separate material by using positive and negative charges. The final step will be a patented controlled crystallization that changes the product from a liquid to solid state for ease of packaging

The Grant Project

The goal of this project was to test various agricultural byproducts, low value, and produce higher value products. The focus of the grant project was to research the feasibility of extracting L-Arabionse, Galactose, Xylose, Mannose and Pectin from distiller's grain from both a dry

milling process, a wet milling process and from sugar beet pulp. ACE BioRefining, LLC, spent over $178,000 to test and refine process. ADD Grant funds were instrumental in determining the correct feedstock to use and correct sizing of equipment needed to commercialize the process.

As a result of project work, ACE Biorefining determined the controlled crystallization process at 20% industrial size worked as hypothesized and it is feasible to build the full size commercial plant. The commercialization plant can be built and equipped with at estimated cost of about 11 million dollars whereas prior estimates from earlier micro testing suggested the cost to be about 22 million dollars. ACE BioRefining plans to order equipment and will commence plant construction as soon as the state air permitting can be obtained. Permitting is being worked on now. This plant will be the first in the world to extract the products at a more cost effective manner that any existing competitor. ACE estimates the cost to produce the high value products will be at about 10% of the current wet chemical processing. The wet chemical process is about ten times more costly and because a great deal of sulfuric acid is used in the process getting the required permits would be prohibitive in Wisconsin.

Originally the thought was that the dry mill distillation grains would be the best source for the biorefining process. As a result of the project, however, we found the corn fibers had too many impurities and the cost to eliminate those impurities is not cost effective at this time. If dry milled distiller grains were to be used as the feedstock, it would require an additional investment of about 1.5 million dollars for a waste treatment plant as part of the commercialized facility. If wet mill distiller's grain were used it would require a smaller waste treatment plant at about $750,000. Sugar beet pulp could be processed in a closed loop system avoiding costly waste water treatment.

It appears the most cost-effective byproduct to extract the product would be using sugar beet pulp followed by distiller's grain from a wet mill and the third was distiller's grain from a dry mill. Although, we are disappointed the use of dry mill distiller grains as a feedstock appears to be not economically feasible, we will continue to work to perfect the process of using distillers grain for other value added products and hopefully this research will expand the demand for distillers grain.

Our results also suggest that cranberry pulp may be a valuable feedstock for biorefining. In fact, there may be many potential agricultural pulp type products that can be used as a feedstock for biorefining. Testing is an ongoing process and depending on market conditions, we may change the feedstocks we use to cranberry pulp or several other feedstocks after the initial plant operation.

The benefits of a biorefining plant to the State of Wisconsin are significant. The plant will be located in a rural setting and some 35 local rural residents will be hired at an entry salary of about $15 per hour with full benefits. Additionally, our laboratories will continue research to find more cost-effective way to extract the same high-value products from dry distiller's grain and other agricultural by-products. And, the State will directly benefit because it will help grow the state economy of a company that will have about 19 million dollars of revenue per annum.